2. Reducing Emissions from Electricity Supply

The electric utility sector produces more than 1.9 billion metric tons of carbon dioxide emissions per year—slightly more than one-third of all U.S. carbon dioxide emissions. Emissions result from the combustion of fossil fuels—coal, oil, and natural gas—during electricity generation. Coal, which accounts for 88 percent of utility emissions, is the primary energy source for U.S. electricity generation (about half the total) and has the highest emissions per unit of energy used. When it is burned, coal emits about 70 percent more carbon dioxide per unit of energy consumed than does natural gas.

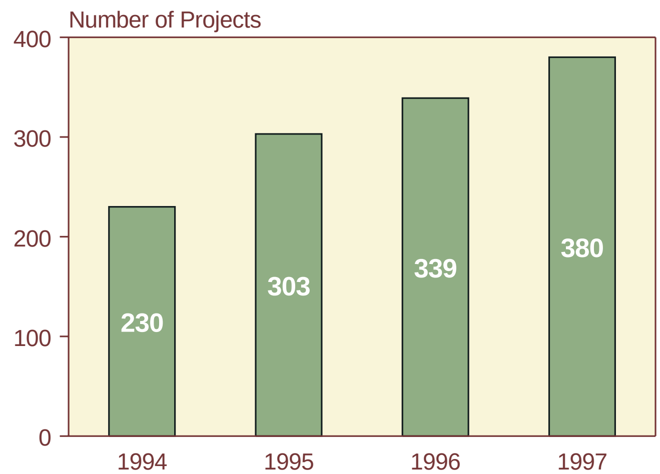
Between 1990 and 1997, carbon dioxide emissions from the utility sector[12] increased by 204 million metric tons or 11.6 percent—a trend that reflects U.S. economic growth and corresponding increases in energy consumption. Electric utility carbon dioxide emissions grew at a faster rate than total energy consumption, which increased by 9.9 percent between 1990 and 1997; however, both utility emissions and total energy consumption grew more slowly than the U.S. economy (18.5 percent).

Overview of Projects Reported

Electricity supply projects are the most numerous reported to the Voluntary Reporting Program, accounting for 31 percent of all projects reported for 1997. Electricity supply projects include such actions as fuel switching, heat rate improvements, and reductions in the line losses associated with electricity transmission and distribution. A total of 380 electricity supply projects were reported by 104 different organizations, a 12-percent increase from the previous reporting year and a 65-percent increase from the first (1994) reporting cycle (Figure 2). Twenty-one new projects were reported as having been undertaken in 1997—a slight increase over 1996 (18 new projects reported) but a decline from previous years (49 new projects in 1994 and 44 in 1995).

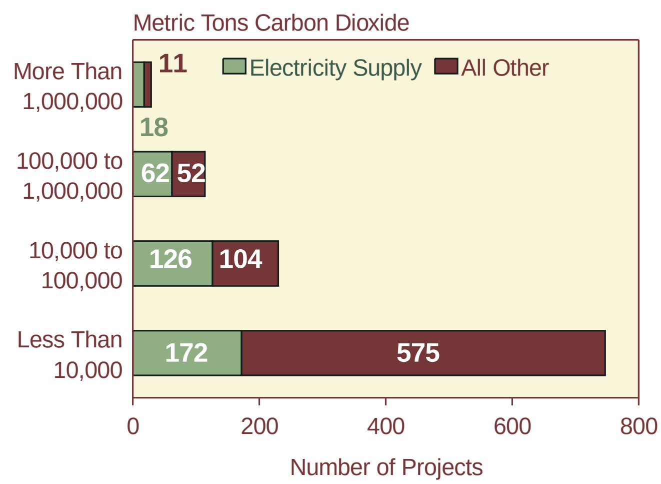
More than one-half of all electricity supply projects reported for 1997 achieved estimated carbon dioxide reductions in excess of 10,000 metric tons each. Of the 29 projects in the largest size category (more than 1 million metric tons of carbon dioxide reductions in 1997), 18 were electricity supply projects (Figure 3).

Figure 2. Reported Electricity Supply Projects, Data Years 1994-1997



Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

Figure 3. Reported Electricity Supply Projects Compared to All Other Projects by Size of Reduction or Sequestration, Data Year 1997



Note: The project sizes shown are only for reported carbon dioxide reductions. "All Other" includes only projects that reported carbon dioxide.

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

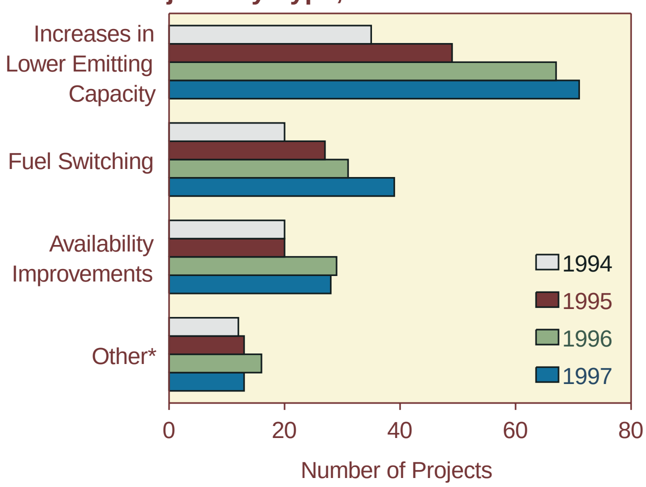
[12]Excluding independent power producers and cogeneration facilities.

Projects undertaken by the electric utility industry usually reduce emissions in one of two ways. They may displace higher emitting fossil fuels (e.g., coal) with lower emitting fuels (e.g., natural gas) or non-emitting energy sources (hydropower, geothermal, solar, wind, and nuclear). Or, by improving the efficiency of electricity generation, transmission, and distribution, they may reduce the quantity of fossil fuel used by power plants. The following sections consider these two groups of projects separately.

Reducing the Carbon Content of Energy Sources

Fuel-switching projects, power plant availability improvements, and increases in low- or zero-emitting capacity typically reduce the amount of carbon consumed to generate a unit of electricity. A total of 151 such projects were reported for 1997 (Figure 4), including some of the largest projects reported to the Voluntary Reporting Program. It should be noted that some carbon content reduction projects are in fact "hybrids," combining efficiency improvements with measures such as availability improvements or increases in low-emitting capacity (see box on page 13 for definitions).

Figure 4. Reported Carbon Content Reduction Projects by Type, Data Years 1994-1997



*Other = decrease in high-emitting capacity and dispatching changes.

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

Availability Improvements

By increasing generation from lower emitting power plants, availability improvement projects provide a commensurate reduction in the amount of generation supplied by higher emitting plants. The number of availability improvement projects reported for 1997 was 28, one less than the 29 reported for 1996 (Figure 4). As has been the case in previous reporting years, availability improvement projects were once again among the most effective in terms of the magnitude of impact on carbon dioxide emissions. On average, availability improvements reduced carbon dioxide equivalent emissions by approximately 1.3 million metric tons per project in 1997.[13]

Availability improvement projects primarily reflect developments within the nuclear power industry. Of the 28 availability improvement projects reported, 17 involved nuclear power plants. Mainly through significant advances in operating, maintenance, and refueling procedures, capacity factors at nuclear plants were increased, displacing fossil-based power generation. Because nuclear power plants are invariably large baseload facilities, even a fairly small improvement in plant availability can lead to a sizable reduction in fossil fuel consumption.

Examples of specific actions taken to improve nuclear plant capacity factors include:

- Efforts by American Electric Power, Inc., to increase the availability of its nuclear units through an intensive program to reduce forced outage rates and shorten the downtime associated with the refueling cycle
- Efforts by Illinois Power Company to improve the availability of its Clinton Power Station by reducing forced outages and shortening the length of refueling outages.

Fuel Switching

Thirty-nine fuel-switching projects were reported,[14] up from 31 in the previous reporting year and 27 in 1995. Twenty of the projects involved switching from coal to other fuel types. Fuels used in place of (or co-fired with) coal included natural gas, waste oil from transformers, wood waste, and fuel derived from discarded tires. Because coal is the highest emitting fossil fuel, switching from coal to other fuels lowers carbon dioxide emissions. For example, switching from bituminous coal to natural gas will reduce carbon dioxide emissions per unit of energy consumed by approximately 43 percent. Although other reported actions, such as switching from oil to gas, may not lead to reductions of the same magnitude, they too will reduce emissions. Average carbon

[13]Estimates of average reductions across reporters should be viewed with caution. Reporters may not calculate reductions in the same way, and multiple reporters may report on some of the same activities (if, for example, a project is undertaken jointly by two or more reporters). Averages are presented only to provide a rough indication of the relative sizes of different types of projects.

[14]Some of these projects were "hybrids," combining fuel switching with other project types.

dioxide emission equivalent reductions on the order of 87,000 metric tons per year were achieved as a result of the fuel-switching projects reported for 1997.[15]

The 39 reported fuel switching projects included a few new projects initiated in 1997. Illinois Power Company conducted a demonstration of the use of a new fuel, orimulsion, at its Hennepin power plant. Orimulsion is an emulsion consisting of 70 percent bitumen and 30 percent water, with fluid properties similar to those of residual fuel[16] and a carbon content of approximately 45 pounds per million Btu. The demonstration was conducted between September and November 1997. Although the project was undertaken primarily to control emissions of nitrogen oxide, the orimulsion displaced coal that would otherwise have been burned, and hence carbon dioxide emissions were also reduced by approximately 1,100 metric tons. The demonstration project has been completed, and Illinois Power is currently analyzing its technical and economic results.[17] The use of orimulsion may be resumed in the future as part of a nitrogen oxide emissions compliance strategy.

NIPSCO Industries also conducted a fuel-switching test at its generating station in Michigan City, Indiana. For the test, coal was co-fired with biomass (specifically, wood waste). Because biomass is a renewable fuel, the carbon it contains is considered part of the natural carbon cycle, and carbon dioxide released during its combustion does not add to atmospheric concentrations of carbon dioxide. NIPSCO conducted nine biomass co-firing tests over a 4-day period in September 1997. The resulting decrease in coal consumption reduced carbon dioxide emissions by approximately 1,300 metric tons. Although the initial tests were completed in 1997, NIPSCO subsequently began a long-term testing program involving three 30-day tests and, potentially, a 6-month test.[18]

Finally, Northern States Power Company converted two of the six combustion turbines at its Wheaton power plant in Wisconsin from oil to natural gas. Per British thermal unit (Btu) of energy produced, oil emits 27 to 33 percent more carbon dioxide than natural gas. The conversions at the Wheaton plant in the summer of 1997 resulted in a carbon dioxide emission reduction of approximately 1,100 metric tons. In addition, Northern States Power estimates that the project reduced nitrous oxide emissions by approximately 0.05 metric tons. Methane emissions increased slightly (0.2 metric tons) as a result of the project.

Electricity Supply Carbon Reduction Projects: Definitions and Terminology

The combustion of fossil fuels to produce heat for electricity generation causes greenhouse gas emissions. In addition to substantial releases of carbon dioxide, fossil fuel combustion also emits small quantities of methane and nitrous oxide. Carbon content reduction projects typically reduce greenhouse gas emissions by replacing higher emitting fuels (such as coal) with cleaner burning fuels (such as natural gas) or non-emitting energy sources (such as nuclear power or renewables). Projects that reduce the carbon content of electricity supply include the following.

Availability Improvements. By reducing the frequency and length of planned and unplanned power plant outages, availability improvement projects can result in increased use of the affected plant. This is particularly true if the plant is a *baseload* plant (i.e., a plant that is generally used on an around-the-clock basis except during plant outages), but it may hold true for other types of plants as well. If the resulting increase in generation from the affected plant displaces generation that otherwise would have been produced by a higher emitting plant, emission reductions will result. Power plant utilization is measured by the plant's *capacity factor*, defined as the ratio of the average load on the plant over a given period to its total capacity. For example, if a 100-megawatt plant operates (on average) at 75 percent of capacity (i.e., at a load of 75 megawatts) over a period of a year, the plant's capacity factor is 75 percent.

Fuel Switching. The amount of carbon contained in fossil fuels and released in the form of carbon dioxide during combustion varies, depending on the type of fuel. Thus, carbon dioxide emissions from a power plant can be reduced by switching from a higher emitting fuel (such as coal) to a lower emitting fuel (such as natural gas).

Increases in Lower Emitting Capacity. By increasing the capacity of an existing lower emitting or non-emitting plant (e.g., a hydroelectric plant), or by constructing new generating capacity (e.g., wind turbines), a utility can reduce or avoid reliance on higher emitting plants. The result will be a reduction in greenhouse gas emissions from the displaced plants.

[15]This average excludes the effects of one fuel-switching project reported by Integrated Waste Services Association, a trade association which reported on the emissions impacts of U.S. waste-to-energy facilities on behalf of its members. Because this project covers numerous facilities and affects landfill methane emissions as well as power plant emissions, its associated emission reductions differ greatly from those of the other fuel-switching projects reported; therefore it was excluded from the average as being unrepresentative.

[16]Personal Communication with Jim Smithson of Illinois Power, March 17, 1999.

[17]Personal Communication with Jim Smithson of Illinois Power, March 17, 1999.

[18]Personal Communication with Patty Hus of NIPSCO, March 18, 1999.

Increases in Lower Emitting Capacity

Projects involving the construction of new, lower emitting power plants or increases in the capacity of existing lower emitting plants were among the most numerous electricity supply projects reported. A total of 71 such projects were reported for 1997,[19] up from 67 reported for 1996 and 35 for 1994. Most involved the installation of new nuclear, renewable, and hydropower capacity, with essentially no greenhouse gas emissions; 7 projects involved additional natural-gas-fired capacity.

In general, most of the projects reported were either small additions to existing power plants or the opening of new plants, primarily small renewable plants. The emission reductions achieved therefore tended to be small in comparison with those for availability improvement projects. Two major exceptions involve the Browns Ferry and Watts Bar nuclear plants owned by the Tennessee Valley Authority (TVA). Browns Ferry Units 2 and 3, which had been shut down in 1985, were reopened in 1991 (Unit 2) and 1995 (Unit 3). The emission reductions resulting from their reopening increased steadily from about 3.5 million metric tons in 1991 to 9.3 million metric tons in 1995. In 1996, the first full year of operation for Unit 3, estimated emission reductions jumped to 15.8 million metric tons for the two units.

TVA's Watts Bar Nuclear Plant Unit 1, a new unit, began commercial service in March 1996. By displacing fossil-fired generation, Watts Bar reduced carbon dioxide emissions by 5.5 million metric tons in 1996 and 7.1 million metric tons in 1997. Although in 1996 TVA had projected total emission reductions from the Browns Ferry and Watts Bar projects at more than 16 million metric tons per year, actual reductions in 1997 were estimated at 22.9 million metric tons—equal to 1.2 percent of all carbon dioxide emissions from the U.S. electricity sector in 1997.

Other Carbon Reduction Projects

Thirteen other carbon reduction projects were reported (down from 16 for 1996), including 9 projects involving decreases in higher emitting capacity and 4 involving changes in the dispatching of power plants. The demand for electricity is not constant but fluctuates according to such factors as time of day and season. Individual power plants are brought on line or taken off as demand fluctuates. The order in which power plants are used or dispatched is generally determined by economics; i.e., the plants that can be operated at the lowest cost are dispatched first, and the highest cost plants are last in the dispatch order. Changes in the dispatch order can reduce carbon dioxide emissions when lower emitting plants are moved up in the order and used more frequently.

As an example, Southern California Edison (SCE) reported three projects involving their purchase of electricity from independent power producers (IPPs). Because the IPPs generated the power using new (post-1990) renewables facilities (specifically, biomass, geothermal, and wind facilities), the power purchases effectively represented a change in SCE's dispatch order. Specifically, the renewable energy displaced SCE's marginal natural-gas-fired generating stations. It should be noted that the IPPs that generated the power were classified as "qualifying facilities" under the Public Utility Regulatory Policies Act of 1978 (PURPA). Under PURPA, electric utilities are required to purchase power from such qualifying facilities. SCE estimated that, in 1997, carbon dioxide emissions were reduced by about 500,000 metric tons as a result of the three dispatching projects.

The 1997 report from General Public Utilities Corporation (GPU) provides examples of projects involving decreases in higher emitting capacity. GPU reported the retirement of generating units at the oil / gas-fired Gilbert, oil / gas-fired Sayreville, coal-fired Front Street, oil-fired Werner, and coal-fired Williamsburg power plants as five separate projects. Total emission reductions for the five projects were estimated at 368,000 metric tons of carbon dioxide in 1997.

Increasing Efficiency in Electricity Production and Distribution

Reported projects that improved the efficiency of electricity generation, transmission, and distribution were both more numerous and smaller than the other electricity supply projects reported. Efficiency improvement tends to be an ongoing effort by electric utilities, yielding a continuous stream of small, incremental improvements rather than one-time dramatic increases in efficiency. For example, heat rate improvement projects often are undertaken in response to normal plant deterioration. As power plants age, efficiency tends to erode gradually. Utilities seek to maintain heat rates by replacing old, worn-out equipment. Similarly, new energy-efficient transformers are often installed gradually over a period of years, as old transformers fail.

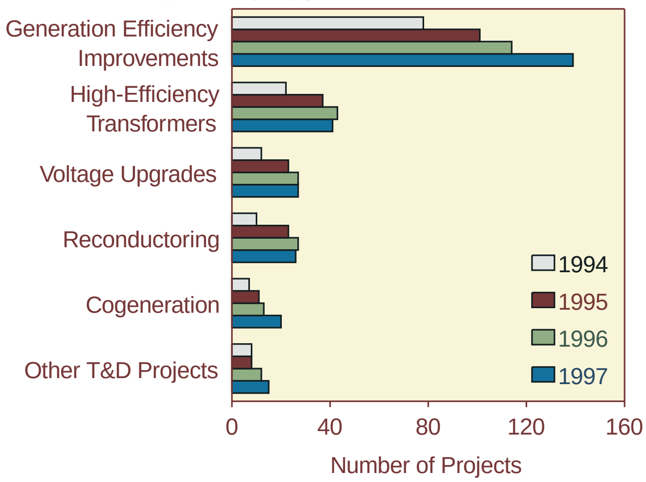
Although the impact of any one efficiency project on carbon dioxide emissions may be relatively small, their combined potential is significant. Consider, for example, electricity transmission and distribution. Among U.S. utilities, energy losses from transmission and distribution typically are in the range of 5 to 10 percent and average about 7 percent. The carbon dioxide emissions associated with the lost energy total about 127 million metric tons per year (based on the average fuel mix for the United States). Hence, a reduction of one percentage

[19]Some of these projects were "hybrids," combining capacity additions with other project types.

point in transmission losses for the United States as a whole would yield an annual reduction in emissions of 18 million metric tons. This is a sizable quantity, representing 0.9 percent of the total carbon dioxide emissions of U.S. electric utilities in 1997 and approximately two-thirds of the projected annual growth in utility emissions.[20]

A total of 272 efficiency improvement projects were reported for 1997, including some "hybrid" projects that combined efficiency improvements with measures such as availability improvements. Efficiency improvement projects fall into two main categories: (1) generation, involving efficiency improvements in the conversion of fossil fuels and other energy sources into electricity; and (2) transmission and distribution, involving improvements in the delivery of electricity from the power plant to the end user (see box on page 16 for definitions). For 1997, 159 generation projects and 113 transmission and distribution projects were reported (Figure 5).

Figure 5. Reported Efficiency Improvement Projects by Type, Data Years 1994-1997



Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

Generation Projects

Efficiency Improvements. Improvements in generating efficiency are the most numerous type of efficiency project reported (Figure 5). A total of 139 such projects were undertaken in 1997,[21] up 22 percent from the number reported for 1996 and 78 percent from the number reported in the first (1994) reporting cycle. Heat rate improvements at coal-fired power plants are a particularly popular means of increasing efficiency and reducing emissions. The average carbon dioxide equivalent emission reduction per project was roughly 70,000 metric tons per year, making these projects somewhat larger than transmission and distribution projects but significantly smaller than the fuel switching, availability improvement, and other electricity supply carbon reduction projects discussed in the preceding section.[22] There are numerous opportunities for improving efficiency at existing power plants, but the efficiency gains—and hence reductions in fuel consumption and emissions—are limited by technology and tend to be small. Even in the context of long-established technologies (e.g., coal-fired steam plants) efficiency gains were reported for a wide range of projects. Reported heat rate improvements typically were between 0.5 and 2.5 percent.

New projects undertaken in 1997 provide some examples of the types of improvements made and the magnitude of the resulting efficiency gains:

- Western Resources, Inc., upgraded the boiler controls for Unit 3 at its Jeffrey Energy Center. The new control system is digital. Western Resources estimates that the new system improved the unit's heat rate by 0.5 percent and reduced its carbon dioxide emissions by nearly 8,000 metric tons.
- Entergy Services, Inc., replaced the high-pressure feedwater heater for Unit 1 at its White Bluff power plant, resulting in a 2-percent heat rate improvement and a carbon dioxide emission reduction of approximately 67,000 metric tons.

Cogeneration. A total of 20 cogeneration projects were reported this year—nearly three times the 7 reported in the first reporting cycle. The average carbon dioxide equivalent emission reduction resulting from cogeneration projects was about 170,000 metric tons in 1997, making cogeneration projects the largest of the various efficiency improvement projects but smaller than the electricity supply carbon reduction projects described in the preceding section.[23] Some of the industrial partners in the cogeneration projects include a grain processor, a greenhouse, a chemical plant, a food processing plant, and a steel mill. Eleven of the projects used

[20]Based on the reference case projection of carbon dioxide emissions in 2020 from EIA's *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998), Table A19, p. 136, http://www.eia.doe.gov/oiaf/aeo99/homepage.html. This projection assumes that carbon dioxide emissions remain unregulated.

[21]Some of these projects were "hybrids," combining efficiency improvements with other project types.

[22]Estimates of average reductions across reporters should be viewed with caution. Reporters may not calculate reductions in the same way, and multiple reporters may report on some of the same activities (see Appendix B). Averages are presented only to provide a rough indication of the relative sizes of different types of projects.

[23]Estimates of average reductions across reporters should be viewed with caution. Reporters may not calculate reductions in the same way, and multiple reporters may report on some of the same activities. Averages are presented only to provide a rough indication of the relative sizes of different types of projects.

Efficiency Projects: Definitions and Terminology

Generation Projects

It is neither theoretically nor practically possible to convert all the thermal or other energy produced by a power plant into electrical energy. In fact, much of the energy is lost rather than converted. Typically, U.S. steam-electric generating plants operate at efficiencies of about 33 percent, meaning that two-thirds of the thermal energy produced is lost. Some more advanced power plants have higher efficiencies, but even new combined-cycle plants (in which the waste heat from a gas turbine is recovered to produce steam to drive a turbine) typically have efficiencies of only 50 to 60 percent. Generation projects seek to improve power plant efficiencies either by reducing the amount of energy lost during the conversion process or by recovering the lost energy for subsequent application.

Efficiency Improvements. By increasing the efficiency of the generation process, efficiency improvement projects at fossil-fuel-fired power plants reduce the plants' *heat rate*, defined as the amount of fossil energy (measured in Btu) needed to produce each kilowatthour of electricity. The result is a reduction in the amount of fuel that must be burned to meet generation requirements, and hence a reduction in carbon dioxide (and other greenhouse gas) emissions. Efficiency improvements at nonfossil (e.g., hydroelectric) power plants can also reduce greenhouse gas emissions. Emission reductions occur if the efficiency improvement leads to an increase in the amount of electricity generated by the affected plant, with a consequent reduction in the amount of electricity that must be generated by other (fossil fuel) plants to meet demand.

Cogeneration. Only a portion of the heat generated during the combustion of fossil fuels can be converted into electrical energy; the remainder is generally lost. Cogeneration involves the recovery of thermal energy for use in subsequent applications. Cogeneration facilities typically employ either topping or bottoming cycles. In a *topping cycle*, thermal energy is first used to produce electricity and then recovered for subsequent applications. Topping cycles are widely used in industry as well as utility power plants that sell electricity and steam to customers. In a *bottoming cycle*, the thermal energy is first used to provide process heat, from which waste heat is subsequently recovered to generate electricity. Bottoming cycle applications are less common, usually associated with high-temperature industrial processes. Because cogeneration involves the recovery and use of thermal energy that would otherwise be wasted, it reduces the amount of fossil fuel that must be burned to meet electrical and thermal energy requirements, hence reducing greenhouse gas emissions.

Transmission and Distribution Projects

The purpose of the electricity transmission and distribution system is to deliver electrical energy from the power plant to the end user. Resistance to the flow of electrical current in cables, transformers, and other components of the transmission and distribution system causes a portion of the energy (typically about 7 percent) to be lost in the form of heat. Improving the efficiency of the various system components can decrease such "line losses," reducing the amount of generation required to meet end-use demand and, thus, power plant fossil fuel consumption and greenhouse gas emissions.

High-Efficiency Transformers. Transformers, used to change the voltage between different segments of the transmission and distribution system, are a major source of system losses. Transformer losses occur as a result of impedance to the flow of current in the transformer windings and because of hysteresis and eddy currents in the steel core of the transformer. When existing transformers are replaced with high-efficiency transformers (including improved silicon steel transformers and amorphous core transformers), losses are reduced.

Reconductoring. Like transformers, conductors (including feeders and transmission lines) are a major source of transmission and distribution system losses. In general, the smaller the diameter of the conductor, the greater its resistance to the flow of electric current and the greater the consequent line losses. Reconductoring involves the replacement of existing conductors with larger diameter conductors.

Distribution Voltage Upgrades. Line losses are dependent, in part, on the voltage at which the various segments of the transmission and distribution system operate. Upgrading the voltage of any segment can reduce line losses.

natural-gas-fired cogeneration systems, one used coal, and the remainder used various other fuel types (such as blast furnace gas). Reported end uses of the thermal energy included electricity generation, process heat applications, and space heating / cooling.

Two new cogeneration projects were reported in 1997. One was reported by NIPSCO Industries, an investor-owned utility serving the northern Indiana region. NIPSCO's service territory includes the heavily industrialized vicinity of Gary, Indiana, long a steel-producing center. With National Steel as its partner, NIPSCO installed a steam turbine / generator, a heat recovery steam generator, two auxiliary boilers, and a water treatment system at its Portside Energy facility. The new gas-fired cogeneration system produces approximately 55 megawatts of electricity, displacing power that would otherwise have been produced by NIPSCO's coal-fired power plants. In addition, the project provides steam and hot water to National Steel, thus replacing the gas-fired boilers that were previously used for this purpose. Although the cogeneration system did not begin operating until September 1997, it nonetheless yielded an estimated emission reduction in excess of 50,000 metric tons of carbon dioxide.

Although begun in 1996, another cogeneration project was reported for the first time for 1997. The project, undertaken at the Bynov district heating plant in the Czech Republic, was actually reported by three different U.S. utilities—NIPSCO, UNICOM, and Wisconsin Electric Power Company—each of which provided an interest-free loan to finance the project in exchange for one-third of the project's emission reduction credits. The credits are to be awarded under the U.S. Initiative on Joint Implementation (USIJI), following annual certification of the emission reductions by the Czech Ministry of Environment. The project consists of a fuel switch from coal to gas at an existing cogeneration facility. Specifically, the lignite-fired boilers at the Bynov plant were replaced with highly-efficient natural gas engines. In addition, heat exchange equipment and an insulated heat distribution network were installed. The Bynov plant generates electricity as well as steam used for district heating in the city of Decin. In addition to the impact of the fuel switch, the project will reduce emissions by improving plant efficiency; it is expected that energy consumption will be cut by 30 percent as a result of efficiency gains. In 1997, each of the three U.S. partners in the project reported 2,654 metric tons as its share of the project's carbon dioxide emission reduction; hence, the total project reduction was equal to nearly 8,000 metric tons.

Transmission and Distribution Projects

Transmission and distribution projects, although not as frequently reported as generation projects, were nonetheless reported in significant numbers. Reported transmission and distribution projects remained at 109 in 1997, a 20-percent increase from 1995 and a 100-percent increase from 1994 (Figure 5). Only one new transmission and distribution project was initiated in 1997. Unlike generation projects, which typically have discrete start and completion dates, efforts such as upgrading conductors and replacing transformers are ongoing activities by electric utilities. Consequently, most of the transmission and distribution efficiency improvements made in 1997 were reported as continuations of long-standing projects rather than as new projects.

In terms of average emission reductions, transmission and distribution projects typically are somewhat smaller than generation projects. There are numerous opportunities for improving efficiencies in the delivery of electricity, but the magnitude of the efficiency gains that can be realized is limited.

The three most frequently reported types of transmission and distribution projects were (1) high-efficiency transformers (including improved silicon steel and amorphous core transformers), (2) reconductoring (replacing existing conductors with large-diameter conductors to reduce line losses), and (3) distribution voltage upgrades (increasing the voltage at which the various segments of the system operate, to reduce line losses). Figure 5 shows the number of reported projects of each type. Installation of high-efficiency transformers was the most frequently reported. A total of 41 such projects were reported for 1997, down slightly from the 43 reported for 1996. Many of these projects were "hybrids," combining high-efficiency transformer installation with one or more other activities (e.g., reconductoring).

Twenty-six projects involving reconductoring and 27 projects involving distribution voltage upgrades (again often in combination with other activities) were reported. Fifteen projects were classified as "general" or "other" transmission and distribution by the reporters, up from 12 in 1996.

The sole new project undertaken in 1997, reported by Northern States Power Company, involved an upgrade at the company's Kohlman Lake Substation. Three 345-kilovolt breakers were installed at the substation, along with associated buswork and protective equipment. The project yielded an estimated reduction of about 10,000 metric tons of carbon dioxide in 1997.

Reported Coal Ash Reuse Projects

Coal ash, a byproduct of coal combustion, continues to be a usable commodity for the electric utility industry. In 1997, 17.5 million metric tons, or 32 percent of total coal ash produced, were used in a wide range of applications.[a] The most conventional use of coal ash is as a replacement for portland cement in the manufacture of concrete. Concrete manufacturing is the largest industrial process source of carbon dioxide emissions, and using coal ash as a substitute material has become an environmentally and economically sound method of reducing carbon dioxide emissions. Half of the carbon dioxide reductions are the result of avoided liberation of carbon dioxide during the calcination of limestone; the other half are the result of avoided emissions from the combustion of kiln fuel. Electric utilities sell coal ash produced at their facilities to avoid landfill disposal costs and to meet increasing demand.

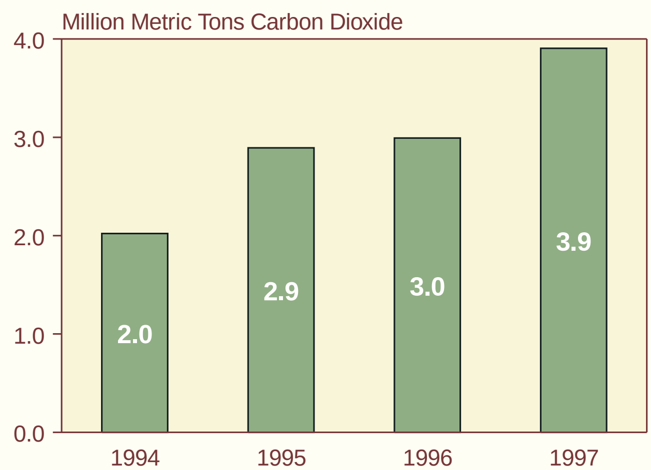
A total of 40 electric utilities reported 43 coal ash reuse projects in the 1997 data year, a 29-percent increase in the number of reporters and a 34-percent increase in the number of reported projects over the 1996 data year. The projects resulted in nearly 4 million metric tons of carbon dioxide reductions, a 30-percent increase over reductions reported for 1996, and contributed 3 percent of the total reported carbon dioxide emission reductions for the 1997 data year. More than 5 million metric tons of coal ash were reported to have been reused, equal to nearly 30 percent of the total coal ash reused nationwide in 1997.

Overall, reductions of carbon dioxide from coal ash reuse projects continued to increase (see figure). The largest reductions from coal ash reuse projects were reported by American Electric Power, Inc. (over 400,000 metric tons) and by Central and Southwest Corporation (over 300,000 metric tons). All the reported projects focused on the sale of coal ash as a substitute for portland cement in concrete manufacturing. Baltimore Gas and Electric Company and New England Electric System Company also suggested that reduced emissions could result from secondary effects, such as a reduced need to transport raw materials, although neither entity calculated the reductions from secondary effects.

Reporters used different emissions coefficients to estimate their carbon dioxide reductions, ranging from 0.8 to 1.0 ton of carbon dioxide released per ton of coal ash reused. The coefficients varied depending on the fuel used to fire the kilns, the proportion of coal ash used in cement, and the electricity used to grind raw materials. Other coefficients were derived using the ratio of the molecular weights of carbon dioxide and calcium oxide (the chemical compounds involved in the calcination of limestone) and the ratio of the specific gravities of coal ash and cement.

[a]Derived from American Coal Ash Association, *1997 Coal Combustion Product Production and Use*, http://www.acaa-usa.org.

Reported Reductions from Coal Ash Reuse Projects, Data Years 1994-1997



Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

Federal Voluntary Programs for the Electric Utility Industry

Most of the electricity supply projects reported by the utility industry were undertaken at least in part to fulfill commitments made under various federally sponsored voluntary emission reduction programs. Many of the programs have their roots in the President's Climate Change Action Plan (CCAP), which identified nine specific action items aimed at reducing supply-side greenhouse gas emissions from the electric utility sector. The action items are designed to increase the use of natural gas, enhance the commercialization of renewable technologies, improve the performance of hydroelectric generating stations, and improve the efficiency of electricity transmission and distribution systems.[24]

As part of the last goal, the U.S. Environmental Protection Agency (EPA) has launched the Energy Star

[24]President William J. Clinton, *The Climate Change Action Plan* (Washington, DC, October 1993), Summary Table of Actions, Actions 23-31, http://www.gcrio.org/USCCAP/toc.html

Transformers program. Under this voluntary program, electric utilities enter into agreements with the EPA to purchase high-efficiency distribution transformers, and manufacturers commit to produce and market Energy Star distribution transformers. Six of the electricity supply projects reported to the Voluntary Reporting Program were Energy Star Transformer projects. In the area of renewables, the Renewable Energy Commercialization program of the U.S. Department of Energy (DOE) sponsors cost-shared pilot and demonstration projects with utility and industry partners. Renewable technologies covered by the program include geothermal, photovoltaics, wind, and biomass.

The cornerstone of the CCAP for electric utilities is the Climate Challenge program. Administered by DOE, Climate Challenge is a voluntary program in which electric utilities enter into formal agreements that spell out their commitments to reduce greenhouse gas emissions or sequester carbon. The contents of the formal accords vary from utility to utility. They may, for example, include commitments to stabilize overall greenhouse gas emissions at or below 1990 levels or commitments to undertake specific greenhouse gas reduction projects. In addition to the individual utility-DOE accords, the Climate Challenge program has spawned nine separate utility industry initiatives for collective action.

Examples include the Earth Comfort Program, which has the goal of increasing annual sales of energy-efficient geothermal heat pumps; the Utility Forest Carbon Management Program and its affiliated nonprofit UtiliTree Carbon Company, which funds four domestic and international forestry projects; and the International Utility Efficiency Partnership. The other Climate Challenge collective initiatives include the Envirotech charter, the Combined Purchasing Initiative, EV America (electric vehicles), the Electric End Use Efficiency Technology Initiative, Tree Power, and the International Donated Equipment Initiative.

Climate Challenge participants are encouraged to report their emission reduction activities to the Energy Information Administration (EIA). The Climate Challenge program is designed to give individual utilities flexibility in identifying and pursuing the most cost-effective approaches to greenhouse gas reductions.[25] There are currently 124 participants in the Climate Challenge program, representing more than 71 percent of total U.S. electric generating capacity (excluding nonutility generators) and 71 percent of 1990 electric utility carbon dioxide emissions.[26] Most of the electricity supply projects reported to the EIA (89 percent of the total) were included in the reporters' Climate Challenge commitments.

[25]President William J. Clinton, *The Climate Change Action Plan* (Washington, DC, October 1993), Foundation Actions, Launch the Climate Challenge, http://www.gcrio.org/USCCAP/toc.html.

[26]Personal Communication with Larry Mansueti, Office of Utility Technologies, U.S. Department of Energy, March 1999.